Philosophical Transactions

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If theſe Obſervations receive the Countenance of this Learned *Society*, I ſhall think myſelf ſufficiently recompenſed; and am,

Gentlemen, with the higheſt Eſteem,

Your moſt obedient humble Servant,

W. Watſon.

V. *A* Sequel *to the Experiments and Obſervations tending to illuſtrate the Nature and Properties of* Electricity; *in a Letter to the* Royal Society *from the ſame.*

Gentlemen,

Read Oct. 30. 1746.

1. THE favourable Reception wherewith you honour'd ſome Papers I laid before you ſome time ſince, relating to Electricity, emboldens me to trouble you again upon the ſame Subject: And I am the more encouraged ſo to do, as the Progreſs of our Diſcoveries therein, both here and abroad, has been ſo rapid; that what, little more than a Year ago, we conceived to be the *ne plus ultra* of our Inquiries, is now regarded as mere Rudiments.

2. It were treſpaſſing too much upon you, to recount the great Number of Experiments I have made; for which Reaſon I ſhall only take notice of ſuch as are either in themſelves ſtriking, or tend to illuſtrate ſome Propoſition.

3.

3. At the Beginning of laſt Summer I cauſed a Machine to be made for electrical Purpoſes; the Wheel whereof was four Feet in Diameter. In the Periphery of this Wheel were cut four Grooves, correſponding with four Globes of ten Inches Diameter, which were diſpoſed vertically at about three Inches Diſtance from each other. One, two, or the whole Number of theſe Globes might be uſed at Pleaſure. They were mounted upon Spindles of two Inches Diameter, and their mean Motion round their Axis was about eleven hundred times in a Minute. As it is next to impoſſible to have theſe Globes blown and mounted perfectly true, I order'd the Leather Cuſhions, with which they were rubb'd, to be ſtuffed with an elaſtic Subſtance (curled Hair) that the Globes in their Rotations might be as equally rubb'd as poſſible. You might likewiſe cauſe the Globes to be rubb'd by the Hands of your Aſſiſtants; but under a certain Treatment (of which hereafter) the Cuſhions excite equally ſtrong. The Leather Cuſhions were now-and-then rubb'd over with Whiting. As a minute Detail of the Parts of this Machine would take up too much of your Time, I have herewith laid before you a Draught thereof.

4. I lined one of theſe Globes to a conſiderable Thickneſs, with a Mixture of Wax and Reſin, in order to obſerve whether or no the Electricity would be the ſooner or more ſtrongly excited; but I found no Difference in the Power of this Globe from the others, which were without this Treatment.

5. The Power of Electricity is increaſed by the Number and Size of the Globes to a certain Degree;

but by no means in proportion to their Number and Size: Therefore, as the Bodies to be electrified will contain only a certain Quantity of Electricity, of which more largely hereafter; when that Quantity is acquired, which is ſooneſt done by a Number of Globes, the Surcharge is diſſipated as faſt as it is excited.

6. After the Globes had been a few times uſed, I found myſelf Maſter of a much greater Quantity of electrical Power, with much leſs Labour to myſelf, than when I uſed only Tubes. I could attract and repel light Subſtances at a much greater Diſtance than before; fire Spirits of Wine, Camphire, and all other Subſtances whoſe Vapours were inflammable, with great Eaſe, and at any Diſtance, with Non-electrics placed upon Originally-electrics: I could fire them, I ſay, at all times; though not equally eaſy, when the Weather was moiſt.

7. I diſcover'd with this Machine, and communicated to ſeveral Members of this *Society*, ſeveral of the Experiments ſaid to be firſt made by M. *le Monnier* at *Paris*, before the Letter communicating them was received by our moſt worthy *Preſident* from thence.

8. I order'd another Machine to be made for a Friend of mine, which carried a Globe of ſixteen Inches Diameter. I united the Power of this large Globe with that of three of the others before-mention'd, and found the Strokes from the excited Non-electrics not increaſed according to my Expectation. In two Experiments indeed, where the Diſſipation of the whole Power of theſe Globes was viſible as faſt as it was excited, the Effect of this additional

additional Globe was very conſiderable. The firſt was, when two Pewter Plates were held, one in the Hand of an electrified Man, and the other by one ſtanding upon the Floor: When theſe Plates were brought near each other, the Flaſhes of perfectly pure and bright Flame were ſo large, and ſucceeded each other ſo faſt, that, when the Room was darken'd, I could diſtinctly ſee the Faces of thirteen People, who ſtood round the Room. The other was from a Piece of large blunt Wire hanging to the Gun-barrel; from the End of which, when electrified, and any black * Non-electric unexcited was brought near, though not near enough to cauſe a Snap, a Bruſh of blue lambent Flame, totally different from the former, was very conſpicuous when the Room was dark, of more than an Inch long and an Inch thick. I mention that what is held near the Bottom of the Wire ſhould be black, becauſe then you ſee this Flame more ſharp. Here the phoſphoreal Smell might be perceived at a conſiderable Diſtance. If the Back of your Hand was brought ſo near this Wire as to occaſion a Snap, and theſe Snaps were received for ſome time, you would feel them

* In the Courſe of theſe Obſervations, whenever I mention either Originally-electrics or Non-electrics, I always underſtand the whole *Genus* of each. Thus when I mention a Man placed upon Originally-electrics, I am indifferent whether he is ſuſpended either in Lines of dry Silk, Hair, or Wool; or (which is much more convenient) if he ſtands upon Glaſs, Wax, Reſin, Pitch, Sulphur, *&c.* or upon different Mixtures of theſe, if of a ſufficient Thickneſs. As we are now Maſters of a greater electrical Power than heretofore, I have found the Electricity pervade, tho' in very ſmall Quantity, Originally-electrics of above four Inches Diameter.

them like ſo many Punctures upon your Skin, occaſioning red Spots, which have laſted four and twenty Hours.

9. If, when a Perſon is electrified, he brings his Hand upon the Cloaths of one that is not, they both have a Senſation exactly reſembling that of many Pins running into the Skin, which continues as long as the Globes are in Motion. This is moſt perceptible when the Cloaths are of thin woollen Cloth or Silk, animal Subſtances; leſs ſo, when of Linen or Cotton, which are vegetable.

10. If ſome Oil of Turpentine is ſet on fire in any Veſſel held in the Hand of an electrified Man, the thick Smoke that ariſes therefrom receiv'd againſt any Non-electric of a large Surface, held in the Hand of a ſecond Man ſtanding upon an electrical Cake; this Smoke, I ſay, at a Foot Diſtance from the Flame, will carry with it a ſufficient Quantity of Electricity for the ſecond Man to fire any inflammable Vapour. The electrical Strokes have been likewiſe perceptible upon the touching the ſecond Man, when the Non-electric held in his Hand has been in the Smoke of the Oil of Turpentine between ſeven and eight Feet above the Flame. Here we find the Smoke of an Originally-electric a Conductor of Electricity.

11. Likewiſe if burning Spirit of Wine be ſubſtituted in the Place of Oil of Turpentine, and if the End of an iron Rod in the Hand of the ſecond Man be held at the Top of the Flame, this ſecond Man will kindle other warm Spirits held near his Finger. Here we find that Flame conducts the Electricity, and does not perceptibly diminiſh its Force.

12.

12. Theſe two Experiments demonſtrate, that the Opinion of thoſe is erroneous, who ſuppoſe the electrical *Effluvia* to be of a ſulphureous Nature; and that theſe themſelves are ſet on fire at the Snapping obſerv'd, when you bring Non-electrics unexcited to thoſe that are. If their Opinions were true, the electrical *Effluvia* ſhould be deſtroyed by the Flame in both the preceding Experiments; the contrary of which is obſerved.

13. I now proceed to take notice of that ſurpriſing Effect, that extraordinary Accumulation of the electrical Power in a Phial of Water, firſt diſcover'd by Profeſſor *Muſchenbroek*, a Man born to penetrate into the deepeſt Myſteries of Philoſophy: And I hope I ſhall ſtand excuſed, if I enter into a minute Detail of the Circumſtances relating thereto. The Experiment is, that a Phial of Water is ſuſpended to a Gun-barrel by a Wire let down a few Inches into the Water through the Cork; and this Gun-barrel, ſuſpended in ſilk Lines, is applied ſo near an excited glaſs Globe, that ſome metallic Fringes inſerted into the Gun-barrel touch the Globe in Motion. Under theſe Circumſtances a Man graſps the Phial with one Hand, and touches the Gun-barrel with a Finger of the other. Upon which he receives a violent Shock through both his Arms, eſpecially at his Elbows and Wriſts, and acroſs his Breaſt. This Experiment ſucceeds beſt, *cæteris paribus*,

1. When the Air is dry.
2. When the Phial containing the Water is of the thinneſt Glaſs.

3.

3. When the Outſide of the Phial is perfectly dry.

4. In proportion to the Number of Points of non-electric Contact. Thus if you hold the Phial only with your Thumb and Finger, the Snap is ſmall; larger when you apply another Finger, and increaſes in proportion to the Graſp of your whole Hand.

5. When the Water in the Phial is heated; which being then warmer than the circumambient Air, may not occaſion the condenſing the floating Vapour therein upon the Surface of the Glaſs.

14. From theſe Conſiderations it is to be obſerv'd, that this Effect ariſes from electrifying the non-electric Water, included in the originally-electric Glaſs; ſo that whatever tends to make the Outſide of the Glaſs non-electric by wetting it, as, a moiſt Hand, damp Air, or the Water from the Inſide of the Phial, defeats the Experiment, by preventing the requiſite Accumulation of the electrical Power.

15. That a Gun-barrel is abſolutely neceſſary to make this Experiment ſucceed, is imaginary; a ſolid Piece of Metal of any Form is equally uſeful. Nor have I yet found, that the Stroke is in proportion to the Quantity of electrified Matter; having obſerved the Stroke from a Sword as violent as that from a Gun-barrel with ſeveral excited iron Bars * in Contact with it.

16.

* If of ſix Men touching each other, and ſtanding upon Originally-electrics, one touches the Gun-barrel, the whole are electrified; all theſe then muſt be conſider'd, as ſo much excited non-electric Matter. From the Aggregate of all theſe, not more Fire is viſible upon the Touch than from either of them ſingly,

16. I have tried the Effect of increaſing the Quantity of Water in the Glaſſes of different Sizes, as high four Gallons, without in the leaſt increaſing the Stroke. If * Filings of Iron are ſubſtituted in the Room of Water, the Effect is conſiderably leſſen'd. If Mercury, much the ſame as Water; the Stroke is by no means increaſed in proportion to their ſpecific Gravities, as might have been imagined §.

17. The Phial ſhould not be leſs than can conveniently be graſped. I generally make uſe of thoſe, which hold ſeven or eight Ounces, and fill them about four Fifths with Water; and the Stroke from one of theſe, under the ſame Circumſtances, is equally ſtrong with that of a *Florence* Flask held in the Hand, which I have ſometimes made uſe of; though the Glaſs of this laſt is equally thin with that of the Phial, and the Quantity of Water four times as much. That the Stroke therefore is not as the Quantity of Water electrified, is evident from this Experiment. This Fact does not depend upon my Judgment alone, but likewiſe upon the Opinions of ſeveral learned Members of this *Society*, who have experienced the greater and leſs Quantity of Water.

18. If a dry Twig of Birch, or any other Wood, be run through the Cork inſtead of the metallic Wire,

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* For a further Account of the Filings of Iron, made uſe of in this Experiment, ſee *theſe Tranſactions*, Vol. XLV. p. 107,

§ In this Experiment, and in others, wherein we aſſert, that the Stroke is not increaſed in proportion to the Quantity of electrified Matter; it muſt always be underſtood, that the excited Non-electrics themſelves are touched, without being contained in Originally-electrics, as Water in the Glaſs; for otherwiſe (as will hereafter be ſpecified) the Effects of different Quantities of Matter will be very different.

Wire, the Stroke is not greater than is uſually felt from the Gun-barrel without the Application of the Water. The Stroke is likewiſe leſſen'd, if the Phial is held in the Hand with a Glove on.

19. After the Gun-barrel and Phial have been ſufficiently excited, which is done in a few Seconds, the Surcharge is diſſipated; ſo that the continuing the Motion of the Machine ever ſo long after the Saturation is complete, does not increaſe the electrical Force.

20. The Force of the Stroke from the electrified Phial does not increaſe in proportion to the Dimenſions of the Glaſs, or the Number of Globes employed. I have been ſtruck as forcibly with one Phial from a Globe of ſeven Inches Diameter, as when I made uſe of, at the ſame time, one of ſixteen Inches, and three of ten. I have been lately informed, that at *Hamburgh* a Sphere was employed for this Purpoſe a *Flemiſh* Ell in Diameter, without the expected Increaſe of Power.

21. When the Phial is well electrified, and you apply your Hand thereto, you ſee the Fire flaſhes from the Outſide of the Glaſs wherever you touch it, and crackles in your Hand.

22. The Phial may be electrified by applying the Wire therein to the Globe in Motion; after which, if it is graſped in one Hand, and the Wire touched with a Finger of the other, the Stroke is as great as from the Gun-barrel. If you only bring your Finger near the End of the Wire without touching it, you obſerve the ſame Bruſh of blue Flame, as from the Wire hanging to the Gun-barrel, before taken notice of. This inſtantly diſappears upon touching

touching the Wire, though you do not receive a Shock, unleſs at the ſame time you graſp the Phial.

23. If you graſp the Phial with your Hand, and do not at the ſame time touch the Wire, the acquired Electricity of the Water is not diminiſhed. So that, unleſs by Accident or otherwiſe the Wire is touched, the electrified Water will contain its Force many Hours, may be convey'd ſeveral Miles, and afterwards exert its Force upon touching the Wire.

24. If, when the Machine is in Motion, the Phial is hung upon the Gun-barrel, no Increaſe of the Stroke is perceived upon touching the Gun-barrel with your Finger, unleſs at the ſame time the Phial is taken in the Hand.

25. If, when the Gun-barrel and Phial are excited, you graſp the Phial with one Hand, and touch the Gun-barrel with a Piece of any Metal held in the other, the Shock is as great in your Arms as though you touched the Gun-barrel with your Finger; but not the leaſt Shock is felt, if, inſtead of Metal, you touch the Gun-barrel with a Piece of dry Wood.

26. I have felt a very great Stroke, when I hung two Phials to the Gun-barrel, and, graſping them both, brought my Forehead near it. The Shock then was ſo violent, that I ſeem'd ſtunn'd, as though ſtruck on the Head with a great Stick, and I have never ſince choſe to repeat this Experiment. This Increaſe of the electrical Force was owing to the additional Phial, whereby the Points of non-electric Contact were augmented.

27. Likewiſe if a Perſon placed upon Originally-electrics, graſps two Phials, as before-mention'd, and a ſecond Perſon, ſtanding upon the Floor, touches any Part of his Body, a very ſlight Stroke only is perceived. But if the ſecond Perſon, while the Globes are in Motion, places one of his Fingers upon the Hand, or any Part of the naked Body of the firſt, and at the ſame time touches the Gun-barrel with his other Hand; both feel a Shock equal to that juſt now mention'd, but more tolerable, becauſe not felt in the Head, in the Arms only, and acroſs the Breaſt. In this Experiment, it is not neceſſary that the Outſide of the Glaſſes held in the Hands ſhould be dry, as in the former Experiments; becauſe whatever by the Moiſture is communicated to the Man, is ſtopped by the Originally-electrics upon which he is placed. If, inſtead of his Hand, you gently touch the firſt Perſon's Cloaths, you only perceive a ſmall Stroke upon your Finger; but if you preſs his Cloaths cloſe to his Body, you frequently perceive a double Stroke; the one, ſlight from his Cloaths; the ſecond, a violent Shock from his Body.

28. Upon ſhewing ſome Experiments to Dr. *Bevis*, to prove my Aſſertion that the Stroke was, *cæteris paribus*, as the Points of Contact of Non-electrics to the Glaſs, that ingenious Gentleman has very clearly demonſtrated it likewiſe by the following Experiment: He wrapped up two large round-bellied Phials in very thin Lead ſo cloſe as to touch the Glaſſes every-where, except their Necks. Theſe were filled with Water, and cork'd, with a Staple of ſmall Wire running through each Cork into the Water.

Water. A Piece of ſtrong Wire about 5 Inches long, with an Eye at each End, was provided, and at each End of this hung one of the Phials of Water by the ſmall Staple running through the Cork. A ſmall Wire Loop then was faſten'd into the Lead at the Bottom of each Phial, and into theſe Loops was inſerted a Piece of ſtrong Wire like the former. If then theſe Phials were hung acroſs the Gun-barrel and electrified, and a Perſon ſtanding upon the Floor touched the bottom Wire with one Hand, and the Gun-barrel with the other, he received a moſt violent Shock through both his Arms, and acroſs his Breaſt.

29. Theſe Phials may be concealed, and the Shock be more univerſal, in the following manner: The Phials may be placed in a Corner of the Room, and any thing laid over them, ſo as not to touch the upper Wires; then a very fine Wire muſt be ſuſpended to the Gun-barrel, and faſten'd to the upper ſtrong Wire. A ſecond Piece of ſmall Wire, of a ſufficient Length to reach from the Phials almoſt under the Gun-barrel, muſt be faſtened to the lower ſtrong Wire, and this may be conceal'd under a Floor-cloth. The Phials then are electrified; and if a Perſon, placing his Foot upon the Floor-cloth over the Wire which comes from the Bottom of the Phials, touches the Gun-barrel, he receives a moſt terrible Shock. The firſt time I experienced it, was when the Phials were fully electrified, and both my Feet were placed upon the Wire. Upon receiving the Stroke from the Gun-barrel upon my Finger, it ſeemed to me, uſed as I am to theſe Trials, as though my Arm were ſtruck off at my Shoulder,

Shoulder, Elbow, and Wriſt; and both my Legs, at the Knees, and behind near the Ankles. So that, to try the Effects of this Experiment, you muſt be careful of not electrifying the Phials too much. If a dozen or more of theſe Phials, or one very large Bottle, were cover'd over with thin Lead in the above manner, and ſtrongly electrified, and this Electricity were diſcharged by a Man at once in the manner here mention'd, I ſhould dread the Conſequences.

30. We muſt obſerve, that this Shock is not felt, unleſs the Wire, coming from the Bottoms of the Bottles, is touched; and then not, if the Shoes are dry, and of conſequence originally-electric. In this Experiment we ſee the Effects of the Increaſe of the Points of Contact; and it ſeems the more ſurpriſing to thoſe who are not acquainted with the Cauſe, when the Wire is concealed under a Floor-cloth, that the moving of their Feet only one Inch, ſhould occaſion them, all other Circumſtances apparently the ſame, to feel a violent Shock, or none at all. A thick Carpet, inſtead of a Floor-cloth, is liable to prevent the Succeſs of this Experiment, for the ſame Reaſon as dry Shoes. This Experiment may aptly enough be called, the ſpringing an electrical Mine.

31. If, in the former Experiment, the lower ſmall Wire is faſten'd to an iron Rod; and if, when the Phials are ever ſo ſtrongly excited, that Rod is held in the Hand of a Man ſtanding upon the Floor, and with it he touches the Gun barrel, he perceives no Shock, for Reaſons preſently to be aſſigned. But if he takes this iron Rod in one Hand, and touches the Gun-barrel with the other, he then is violently

ſtruck. We muſt here obſerve, that the Violence of the Stroke is always felt in our Bodies, in proportion to the Loudneſs of the Exploſion, and the Quantity of Fire ſeen. Therefore, as both theſe are equally perceptible, whether the Electricity paſſes only thro' the Iron, as in the firſt of theſe Inſtances, or thro' our Bodies equally with the Iron, as in the ſecond; we conclude, that in both there is in the ſame Degree of electrical Force. By the firſt of theſe Methods you are capable of making others ſenſible of the electrical Force, without feeling it yourſelf. This Experiment, as well as the laſt, will admit of infinite Variation.

32. If a Man, ſtanding upon an electrical Cake, takes the Phial ſuſpended to the Gun-barrel in his Hand, by theſe means he acquires ſome electrical Power; for if, under theſe Circumſtances, he touches the Gun-barrel, he only receives a ſlight Stroke. If then, without having had any Communication with unexcited Non-electrics, he touches the Gun-barrel again, the Globes being yet in Motion, he receives no Stroke at all.

33. If to the Gun-barrel an Egg, either raw or boiled, is ſuſpended by a Piece of Wire, and a Perſon, graſping the electrified Phial in one Hand, brings the Palm of his other near the Bottom of the Egg; at that Inſtant he receives a ſmart Stroke, and his Hand ſeems full of a more red Fire than is uſually obſerved. In this Experiment the Stroke is more confined to the Hand without ſhocking the Arms, than when you touch the Gun-barrel itſelf; it more reſembles a Stroke over the Hand with a *Ferula*.

34.

34. If any Number of People ſtand upon Originally electrics, and communicate with each other by any non-electric Medium, eſpecially Metal, they are by theſe means all equally electrified; and if a Perſon ſtanding upon the Floor, and holding the Phial of Water hanging to the Gun-barrel in his Hand, touches the Perſon furtheſt from the Gun-barrel, the whole Number receives a Shock equal to any one touching the Gun-barrel ſingly.

35. If a Number of Perſons, how great ſoever, ſtand upon the Ground, communicating with each other as before, the firſt of which graſps the Phial, and the laſt touches the Gun-barrel, the whole Number receive a Shock like the former. This, we are inform'd, M. *le Monnier* at *Paris* communicated through a Line of Men, and other Non-electrics, meaſuring nine hundred Toiſes.

36. Several Experiments ſhew, that the electrical Force always deſcribes a Circuit; *e. g.* if a Man holds the electrified Phial in one Hand, and touches the Gun-barrel with the other, he feels the Shock in no other Parts of his Body than in his Arms, and acroſs his Breaſt. So that here we ſee the electrical Power darts *rectiſſimo curſu* between the Gun-barrel and Phial. This is more particularly demonſtrated by the following Experiment, in which, though the two Lines of Perſons may be of any Length, we only ſpecify, that each conſiſts of four, for the ſake of Perſpicuity.

37. Of one Line, let *A* (*ſee* TAB. III.) touch the Gun-barrel, ſtanding upon Wax, and communicate with *BCD* likewiſe ſtanding upon Wax. Of the other Line, let 1 take the electrified Phial in his Hand,

Hand and join with 2, 3, and 4, all ſtanding upon the Floor. If, under theſe Circumſtances, the firſt Line is electrified, and 4 touches *D*, all eight are ſtruck through. If 4 touches *C*, *D*, though electrified, feels nothing, and the remaining ſeven are ſtruck; ſo that here *D* is left out of the Circuit. If 4 touches *B*, only ſix feel the Shock, and *C* and *D* feel nothing; and thus you may proceed to *A*, who muſt always neceſſarily feel, if either himſelf or any of his Line is touched. If, when both Lines are as before-mention'd, *D* touches 3, 4 is left out of the Circuit, and the remaining ſeven feel the Stroke. If *C* touches 2, the Circuit conſiſts of five, *D*, 3, and 4 being, though under the ſame Circumſtances, left out: Always obſerving, however theſe Circuits are diverſified, that *A*, who touches the Gun-barrel, and 1, who holds the Phial, are certain to feel the Stroke.

38. This Experiment may be reverſed, the Lines being as before, in the following manner, wherein likewiſe this Circuit is always obſervable. Let *A* (*ſee* TAB. III.) touch the Gun-barrel as before, and *D* hold the Wire of the electrified Phial in his Finger. Let 4 graſp the Phial, and 1 touch *B*; then *A* feels nothing, being left out of the Circuit, and the other ſeven are ſtruck. If 4 touches *C*, then *A* and *B* feel nothing, the Circuit conſiſting of the remaining ſix. But it is to be obſerved, as in the former Experiment, that 4, who graſps the Phial, and *D*, who holds the Wire, muſt of Neceſſity be always in the Circuit. I have been the more particular in this Matter, as it demonſtrates the Courſe of

the electrical Power to be in the moſt direct manner between the Gun-barrel and the electrified Phial.

39. Likewiſe, if a Perſon, ſtanding upon an Originally-electric, touches the Gun-barrel with his right Hand, a Piece of Wire being placed round his left Leg, and a ſecond Perſon, ſtanding likewiſe upon the Wax, takes hold of the Extremity of this Wire; then let another Perſon, ſtanding upon the Floor, and graſping the electrified Phial, touch any Part of the ſecond Perſon's Body. Upon this Touch, the ſecond Perſon is ſhook as uſual; but the firſt feels the Stroke only in his left Leg and right Arm, the neareſt Courſe of the electrical Power.

40. If any Number of Perſons communicate by Pieces of Wire, and if any one of them brings together the Ends of the two Pieces of Wire in his Hands, upon the Gun-barrel's being touch'd, he will perceive no Stroke. But if the Ends of the Wires are but a Quarter of an Inch aſunder, he will be ſhook in both his Arms; becauſe then his Body will become Part of the Circuit.

41. If, when any Number of Perſons join Hands, or communicate by any metallic Medium ſtanding on the Floor, one graſps the Phial, and joins with the reſt; upon the Gun-barrel's being touch'd by the laſt Perſon of the Line, the whole Number are ſtruck, and he who graſps the Phial, as forcibly as the reſt. But if two Phials are employed, and he graſps them both, with a Piece of Wire of ſufficient Length held between his Fingers, which Wire touches both Phials, and its End is taken hold of by the ſecond Perſon of the Line; if then the laſt Perſon touches the excited Gun-barrel, all in the Line

Line are violently ſtruck, except the Perſon who graſps the Phials; but he feels little or nothing of the Stroke.

42. The Stroke is very violent, when a Wire is put round the naked Head, or under the Peruke, and the Perſon graſping the Phial touches the Gun-barrel with the Ends of the Wire, or if he holds the Wire between his Teeth.

43. If a Perſon, ſtanding on the electrical Cakes with Gold or Silver Lace upon his Coat, takes hold of the Gun-barrel, and another Perſon graſping the electrified Phial touches the Bottom of the Lace, the Perſon electrified, if he holds down his Head, feels the Blow under his Chin. The Lace in this Inſtance has the ſame Effects as a Piece of Metal; at the End of which, if placed in the ſame manner, you would neceſſarily feel the Stroke.

44. I now proceed to ſhew, by what Steps, in my Inquiries into the Nature of Electricity, I diſcover'd that the glaſs Tubes and Globes had not the electrical Power in themſelves, but only ſerved as the firſt Movers and Determiners of that Power.

45. Several Months ſince, I obſerv'd that, by rubbing a glaſs Tube, while ſtanding upon a Cake of Wax, in order, as I expected, to prevent any of the electrical Power from diſcharging itſelf through me into the Floor; contrary to my Expectation, that Power was ſo much leſſen'd, that no Snapping was to be obſerv'd upon another's touching any Part of my Body. But if a Perſon not electrified held his Hand near the Tube whilſt it was rubbing, the Snapping was very ſenſible. This I ſhew'd to ſeveral Members of the *Royal Society*,

and others, who did me the Honour to viſit me. Afterwards I met with an Experiment of the ſame kind, in a Treatiſe publiſh'd by Profeſſor *Boſe*, intitled, *Recherches ſur la cauſe et ſur la veritable theorie de l'Electricité*, which that ingenious Gentleman ſays, had given him great Trouble by its Oddneſs. The Experiment is, that, if the electrical Machine is placed upon Originally-electrics, the Man who rubs the Globes with his Hands, even under theſe apparently favourable Circumſtances, gives no Sign of being electrified, when touched by an unexcited Non-electric. But if another Perſon, ſtanding upon the Floor, does but touch the Globe in Motion with the End of one of his Fingers, or any other Non-electric, the Perſon rubbing is inſtantly electrified, and that very ſtrongly. The Solution of this *Phænomenon*, ſeemingly contrary to the already diſcover'd Laws of Electricity, had terribly tormented him; but however he has given us the following, which he modeſtly calls a plauſible Subterfuge rather than a Solution; *viz.* that a Power cannot act at the ſame time with all its Vigour, when one Part of it is already employed; as a Horſe, who already draws an hundred Pounds, cannot draw an additional Weight as freely as if he had not been loaded at all. That the Hand excites the Virtue already in the Sphere; therefore if the ſame Power impregnates the Man, there remains none for the Globe. That the Virtue of the Globe then cannot be communicated at the ſame time to the Man, by whom it is created. That he, who gives it, cannot receive it himſelf. From theſe, and ſuch-like Conſiderations, it appears to him,

him, that the Man upon the Ground, who holds his Fingers to the Globe in Motion, inſtead of his diminiſhing its electrical Force, throws that Force back again over the Man, who excited it. That the Finger in this Caſe ſeems to operate as an Electric *per ſe*, and drives back the electrical Power.

46. I have ſeen an Account of * Mr. *Allamand*, lately printed at the *Hague*; wherein he takes notice of this *Phænomenon*. He tells us, that as Part of the electrical Power of the Globe paſſes off by the Frame, upon which the Globes are mounted, into the Floor, and diſſipated thereby; he conceived, that if the Machine, and the Man who rubb'd the Globe, were placed upon Pitch, to prevent this Diſſipation, the Fire of Electricity would be more ſtrong. But the Conſequence is extremely odd and unexpected; for the contrary happens; and the electrical Power is conſiderably diminiſhed, and ſometimes there is even none at all.

47. I tried this Experiment ſeveral times with my Machine, and the Man, who turns the Wheel thereof, mounted upon the electrical Cakes. If the Air was dry, and the Machine placed at ſome Diſtance from non-electrical Subſtances, as the Sides of the Room, Chairs, and ſuch-like; after one or two ſmall Snaps, the Gun-barrel, ſupported by ſilk Lines, and hanging in Contact with the Globes, would, tho' the Machine were in Motion a conſiderable time, attract

* *Bibliotheque Britannique pour les Mois de Janvier, Fevrier, et Mars*, 1747.

attract no light Subſtances, nor emit any Fire. This induced me to conceive, that the electrical Power was not inherent in the Glaſs, but came from the Floor of the Room; and if the Fact were ſo, the Gun-barrel ſhould ſnap upon my touching any Part of the Machine. The Conſequence fully anſwer'd my Conjectures; for while I ſtood upon the Floor, the Globes ſtill in Motion, I put one Hand upon the Frame of the Machine, and touched the Gun-barrel with one of the Fingers of my other. Upon this, Fire iſſued, and the Snapping continued as long as I held my Hand upon the Machine, but ceaſed upon taking it off. This at once proved to me, that the electrical Fire paſſed from the Floor thro' my Body to the Machine. I then order'd the Man to put one of his Feet from the Wax upon the Floor; which, as ſoon as he complied with, cauſed the Electricity to ſnap at the Gun-barrel, and this ceaſed upon his replacing his Foot. Here I found, that the electrical Power came through the Man; and that, in theſe Inſtances, either myſelf, or the Man who touched the Floor with his Foot, was to be regarded as an additional Part of the Machine communicating with the Floor. Theſe Conſiderations led me to make the following Experiments.

48. If my Conjectures were well founded, and if the electrical Power, the Man and the Machine being placed upon Originally-electrics, went through my Body to the Machine, a fine Wire, held in my Hand at a few Inches Diſtance, ought to be attracted by any Part of the Machine. This ſucceeded accordingly, but the Attraction laſted a very ſmall Space

Space of Time, and the Wire again hung perpendicularly from my Finger, though the Globes continued in Motion. This induced me to believe, that the Gun-barrel, and the other Non-electrics ſuſpended in Contact with the Globes, would only contain a certain Quantity of the electrical Æther; and if this were the Caſe, the Attraction of the Wire to the Machine would be continual, if the electrical Power found again a Communication with the Floor, as the Wire was the only Canal of Communication between the Floor and the Machine. Whereupon I placed one of my Fingers upon the Gun-barrel, and held a Wire near the Machine with my other Hand, and found, that as long as my Finger continued upon the Gun-barrel, the Wire was attracted, but no longer.

49. Here we find, that one Cauſe of the electrical Attraction is the Current of the electrical Æther ſetting to the Machine through the Wire; and this Current is ſtopped from two Cauſes; one, when there is no Diſcharge thereof from the Gun-barrel, the Accumulation being complete; the other, when other Currents are opened, that is, when the Machine is touched in other Parts.

50. In theſe, and the ſubſequent Experiments, I always ſuppoſe the Air very dry; for if it is not, and the ſilk Lines, which ſupport the Non-electrics, are wetted thereby, the electrical Power will be diſcharged along them, and the Wire will be conſtantly attracted, as I have frequently on purpoſe experienced; and this Diſcharge is in proportion as the Lines are more or leſs wetted.

51.

51. If a Man ſtands upon the Machine placed upon Originally-electrics, and the Gun-barrel with the other Non-electrics are ſuſpended as uſual in Contact with the Globes, no Electricity is obſerved in that Man: But if a Wire, hanging to the Wainſcot of the Room, touches the Gun barrel, or a Man ſtanding upon the Floor applies his Finger thereto, the Man upon the Machine emits Fire copiouſly; and either himſelf, or the Man who turns the Wheel of the Machine, fires inflammable Subſtances. But this Effect is no longer obſervable, when the Wire, *&c.* are removed from touching the Gun-barrel. So that, in this Experiment, the uſual Courſe of the Electricity is inverted; and that Power, which, in moſt other Inſtances, is brought by the Wood-work of the Machine to the Globes, and by them diſcharged upon the Gun-barrel, is now brought by the Wire to the Gun-barrel, and from this the Globes throw it all over, not only the Machine, but any Non-electric in Contact with it, if the Electricity is ſtopp'd. In this Experiment, if an iron Rod, ſtanding upon the Floor, is inclined againſt the Loops of the ſilk Lines which ſupport the Gun-barrel, in ſuch a manner as not to touch the Gun-barrel, the electrical Fire, which paſſes from the iron Rod to the Gun-barrel, inſtead of being ſupplied conſtantly, comes in by ſnapping ſo long as any unexcited Non-electric communicates with the Machine, but ceaſes upon its being removed: And if the Air is very dry, and none of the Electricity conducted down the ſilk Lines, the Snapping from the iron Rod to the Gun-barrel will frequently correſpond to the touching of the wooden Machine with your

your Fingers, and ſtop upon your taking them off. And this Experiment will look much like Magic, even to thoſe who are acquainted with the Operations of Electricity; for if the Perſon who turns the Wheel of the Machine, and ſtands upon the Cakes, be properly inſtructed: upon your bidding the Gun-barrel ſnap, he only puts the Toe of his Shoe upon the Floor, and it ſnaps immediately, and continues ſnapping as long as he keeps it there; but if you order it to ceaſe ſnapping, he almoſt imperceptibly replaces his Foot upon the Cakes, and it ceaſes. This may be repeated as often and as long as you pleaſe.

52. Many Experiments demonſtrate, that if the Electricity is not ſtopt, no Sign of its Preſence, either by Fire or Attraction, is obſervable in the non electric Bodies ſuſpended to the Globes: that is, although ever ſo great a Quantity be determined by the Globes over theſe Bodies, the Electricity paſſes off from them *pleno rivo* to the Floor, from whence it came: but if the Electricity is ſtopt, it is then accumulated upon theſe Non-electrics; but this can be done only to a certain Degree, as is manifeſt from a former Experiment. And if, when this Power is accumulated, a Man ſtanding upon the Floor touches now-and-then the Non-electrics with his Finger, the Electricity, which is here accumulated, ſnaps, and the Fire is always obſervable. But this Snapping is not, when the electrical Power paſſes off continually, as from a Piece of blunt Wire hung to the ſuſpended Gun-barrel, and the Hand of a Man brought near it without touching; whereby the electrical Power becomes viſible, like a fine

blue Cone of Flame, with its Point towards the Wire. When the Hand is placed at a proper Diſtance, the Blaſt, like that of cold Air, is therefrom very manifeſt. If you do not determine the Electricity by theſe means to a Point, the Diſſipation of it is general, and from all Parts of the excited Non-electric; but if you do, by bringing your Hand near the Wire as before-mention'd, you ſee the Manner of its being diſcharged into the Floor, and ſo into the Earth. Theſe Facts being ſo, if my Conceptions are true, that the glaſs Globes circulate the electrical Fire, which they receive from their Friction againſt the Cuſhions, or the Hand of a Man, and which is conſtantly ſupplied to theſe laſt from the Floor; the Ingreſs of the electrical Fire. if the Machine, *&c.* are placed upon Electrics *per ſe*, ought to be viſible, as well as the Egreſs under the ſame Circumſtances; and this is demonſtrated by Experiment, For if, while any unexcited Non-electrics touch the Gun-barrel, the Globes being in Motion, you bring your Finger, or a Piece of Wire near any Part of the Wood-Work of the Machine, but more eſpecially the iron Axis of the Wheel; you obſerve the Bruſh of blue Flame ſet in from it to the Wood-Work. We always obſerve, in this Experiment, that the lambent Flame from the End of the Wire paſſes diverging into the Machine, and this continues ſo long as the Gun-barrel is touch'd. So that here the Office of the Globes exactly tallies with that of the Heart in Animals; which, as long as the Quantity of Blood is ſupplied, propels it into the Arteries, and theſe all over the Syſtem; or that of the Pump in Hydroſtatics. In the ſame manner,

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by the Attrition of glaſs Tubes, the electrical Power is brought from the Body of the Man who rubs the Tube; and he is conſtantly taking in a Supply from the Floor.

53. What I here call the electrical Æther, is that Atmoſphere which ſurrounds both excited Originally electrics, and excited Non-electrics. That this is extended to a conſiderable Diſtance, appears, from a fine Thread, or Piece of Cotton-graſs Seed, being attracted at ſome Diſtance from them, as far as which, it is preſumed, this Atmoſphere extends. Here indeed it is only perceived by its Effects upon theſe light Subſtances: but at the Bruſh of Flame from the End of the Wire before-mention'd, from ſome Bran lying upon a flat Piece of Metal in Contact with excited Non-electrics, your Hand being held over it, and in many other Experiments, it becomes manifeſt to your Feeling as a Blaſt of cold Wind. You feel it likewiſe in a leſs Degree, when a glaſs Tube is well excited, and brought near your Face. If no unexcited Non-electric is near, this Atmoſphere ſeems to be determined equally over all the excited Non-electrics in Contact with the Machine; but if a Non-electric unexcited is brought near, the greateſt Part of it is determin'd that way; and hereby the Attraction at any other Part of theſe excited Non-electrics is conſiderably diminiſhed. Hence the Cauſe of the Repulſion of Electricity, which does not operate, until the electrical Æther is ſufficiently accumulated. This electrical Repulſion is ſtrongeſt in thoſe Parts of the excited Non-electrics, where unexcited Non-electrics are brought near them; for by theſe the electrical Blaſt, which

otherwiſe is general, is particularly determined to the Floor.

54. Before I proceed further, I muſt beg Leave to explain what I call the Accumulation of Electricity. To put a ſimilar Caſe: As we take it for granted, that there is always a determinate Quantity of Atmoſphere ſurrounding the terraqueous Globe, we conceive, when we ſee the Mercury in the Barometer very low, that there then is a leſs accumulated Column of this Atmoſphere impending over us, than when we ſee the Mercury high. In like manner when we obſerve that the electrified Gun-barrel attracts or repels only very light Subſtances at a very ſmall Diſtance, or that the Snap and Fire therefrom are ſcarcely perceptible; we conceive then a much leſs Quantity of electrical Atmoſphere ſurrounding the Gun-barrel. This Power being more or leſs, we call the greater or leſs Degree of the Accumulation of Electricity. This is only attainable to a certain Point, if you electrify ever ſo long; after which, unleſs otherwiſe directed, the Diſſipation thereof is general. The Phial of Water of *Muſchenbroek* ſeems capable of a greater Degree of Accumulation of Electricity, than any thing we are at preſent acquainted with: And we ſee, when, by holding the Wire thereof to the Globe in Motion, the Accumulation being complete, that the Surcharge runs off from the Point of the Wire, as a Bruſh of blue Flame. A Method has been diſcover'd here by a Gentleman (Mr. *Canton*) by which the Quantity of accumulated Electricity may be meaſured to great Exactneſs. The Manner of meaſuring is this: When the Phial is ſufficiently electrified by

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applying the Wire thereof to the glaſs Globe, and which is known by the Appearance of the Bruſh of Flame at the End of the Wire, as before-mention'd; hang a ſlender Piece of Wire to the ſuſpended Gun-barrel for this Purpoſe detached from the Globes. Upon your applying the Wire of the electrified Phial to that hanging to the Gun-barrel, you perceive a ſmall Snap; this you diſcharge by touching the Gun-barrel with your Finger, which likewiſe ſnaps: And thus alternately electrifying and diſcharging, you proceed until the whole Electricity of the Water is diſſipated; which ſometimes is not done, under an hundred Diſcharges. If you do not diſcharge the Electricity every time, the Snaps from the Wire of the electrified Phial to the Gun-barrel are ſcarcely perceptible. In proportion to the Number of Strokes, you eſtimate the Quantity of the acquired Electricity of the Water. That you could, by ſtopping the Electricity, excite Non-electrics; and, by accumulating their Power, make them exert more Force than Originally-electrics would at any Point of Time, was that capital Diſcovery of the late Mr. *Gray*; and is to be regarded as the Baſis, upon which all the preſent Improvements of our Knowledge in Electricity are founded; and till which Diſcovery, although ſome of the Effects of Electricity were obſerved above two thouſand Years ago *, little Progreſs was made.

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* *Theophraſtus*, who lived above three hundred Years before the Date of the Chriſtian Æra, takes Notice of Amber and the *Lyncurium*,

55. The electrical Æther is much more ſubtil than common Air, and paſſes to a certain Depth through all known Bodies. It paſſes moſt readily through Metals, Water, and all Fluids, except reſinous ones; then animal Bodies dead or alive, in proportion as they are more or leſs wet; then Stones, Wood, and Earths. It paſſes to a certain Thickneſs only thro' Reſins, dry animal Subſtances, Wax, and Glaſs. For this Reaſon Bodies are called Electrics *per ſe*, or Non-electrics; not only for their rubbing the Electricity from other Bodies, but likewiſe as they permit more or leſs of the electrical Æther to paſs through them. This Æther has not only the Property with Air of moving light Subſtances; but it ſeems to have another, and that is Elaſticity.

56. That this Fluid is more ſubtil than common Air, is more particularly demonſtrated by its paſſing through ſeveral Glaſſes at the ſame time; through any one of which, though ever ſo thin, Air cannot paſs. It likewiſe paſſes, as I have mention'd before, through all known Bodies, except Originally-electrics, and even through theſe to a certain Degree. Its Elaſticity is proved by its extending itſelf round excited Electrics, and excited Non electrics, to a conſiderable Diſtance; as well as by its increaſing the Motion of Fluids. This is demonſtrated by the Experiment with a ſmall glaſs Siphon where the

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curium attracting not only Straws, and Shavings of Wood, but alſo thin Pieces of Copper and Iron. See *Theophraſtus* περὶ τῶν λίθων ν'.
—Καὶ τὸ λυγδινεον — ἑλκει γὰρ ὥσπερ τὸ ἤλεκτρον· Οἱ δὲ φασιν ὐ μόνον κάρφη καὶ ξύλα, ἀλλὰ χαλκὸν καὶ σίδηρον, ἐὰν ᾖ λεπτός· ὥσπερ καὶ Διοκλῆς ἐλεγεν. See *p.* 74. in the late Edit. by *J. Hill.*

the Elaſticity of the electrical Æther overcomes the Attraction of Coheſion: I have frequently obſerved this Experiment does not operate, unleſs the greateſt Part, if not the whole electrical Blaſt, is determined to the Floor through the Water, by bringing ſome unexcited Non-electric near the long Leg of the Siphon †. The Stream through this ſlender Tube is moſt complete, when the Non-electric is brought near, ſo as when the Room is ſomewhat darkened, the Stream of Water appears as a Stream of blue Flame, much like that from the blunt Wire. This Stream is ſtopped, either by touching any Part of the Non-electrics in Contact with the Globes; by placeing the Machine and the Man who turns the Wheel upon Electrics *per ſe*, by which the Current of the electrical Æther from the Floor to the Machine is prevented; or by removing the Non-electric from the Leg of the Siphon, by which the Diſſipation of the electrical Æther from the excited Non-electric becomes general. So that we find, that although we can repel light Bodies from many Parts of excited Non-electrics at the ſame time; the whole Force of the electrical Current is neceſſary, to drive off

† There is one Inſtance, where the Water will run off in a full Stream without bringing a non-electric unexcited near the long Leg of the Siphon; and that is, by ſuſpending a Phial of Water, as uſual to the Gun-barrel by a Wire, and by letting a glaſs Siphon through the Cork into the Water. When this Phial is ſufficiently electrified, the Water therein runs off in a full Stream, though no Non-electric unexcited is near; becauſe then the Current of Water through the Siphon is the only Way, by which the Surcharge of the Electricity can be diſſipated.

off ſo ponderous a Fluid as Water. May we likewiſe not infer the Elaſticity of electrical Æther, from the Ingreſs of the blue Flame from the End of a blunt Wire held near the Axis of the Wheel, or any Part of the Wood-work of the Machine, after the Revolutions of the Globes are ceaſed? Certainly we ſee an Influx of electrical Fire to all Bodies, until their determined Quantity is reſtored. Is not the Elaſticity of this Æther deducible likewiſe from the violent Shock we feel in our Bodies in the Experiments with Water?

57. There ſeems to be a Quantity of this Æther in all Bodies. Hence the Reaſon why, though the Machine is placed upon Electrics *per ſe*, a Snap or two, as I mention'd before, is obſerv'd upon touching the Gun-barrel, when the Machine has been ſome time in Motion: But after theſe no more is perceiv'd, if the ſilk Lines are very dry, and the electrical Supporters of the Machine are of a requiſite Thickneſs. As ſoon as any Non-electric unexcited touches the Machine, this Loſs is immediately reſtored. As the electrical Æther, as has been ſpecified, is an elaſtic Fluid, wherever there is an Accumulation thereof, there is an Endeavour by the neareſt unexcited Non-electric to reſtore the *Æquilibrium*. The reſtoring of this *Æquilibrium* I take to be the Cauſe of the Attraction of excited glaſs Tubes and Globes, as well as that of excited Non-electrics; for here the Blaſt of electrical Æther conſtantly ſets in from the neareſt unexcited Non-electrics towards thoſe excited, and carries with it whatever light Bodies lie in its Courſe. This ſetting in

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of the Current of electrical Æther towards excited Non-electrics is likewiſe very perceptible to your Feeling as a Blaſt of cold Wind; if when you are electrified, you hold your Hand over a Plate with ſome Bran in it, by which Blaſt the Bran is carried againſt your Hand. Theſe light Subſtances are again repell'd by the Blaſt from the excited Bodies, as ſoon as they come in Contact, and ſometimes before. The Succeſſions of theſe alternate Attractions and Repulſions are extremely quick, ſo that ſometimes your Eye can hardly keep Pace with them. And if you put a glaſs Globe of about an Inch in Diameter very light and finely blown into a Plate of Metal, and hang another Plate over it; electrify the upper one, and bring the other under it, and you will find the Strokes from the alternate Attractions and Repulſions * almoſt too quick for your Ear. I have ſeen a *German*, who travell'd with a ſmall electrifying Machine, who, by a Proceſs of this ſort, made two ſmall Bells ring. One of the Bells was ſuſpended to an electrified Wire, which was conducted without touching along the Sides of the Room; at about an Inch Diſtance, detached from this Wire, a little Clapper was hung by a ſilk Line; at an equal Diſtance from this laſt was hung another little Bell, which communicated with the Sides of the Room.

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* The following is an Argument of the Velocity likewiſe, with which theſe little Globes are attracted and repell'd. If they are let fall from the Height of ſix Feet or more upon a wooden Floor, or a Plate of Metal, they are rarely broke; but by the Attractions and Repulſions of them between the Plates, though at the Diſtance only of one ſixth of an Inch, they are frequently beat in Pieces.

As ſoon as the Machine was in Motion, the electrified Bell attracted the Clapper, which immediately by the repulſive Blaſt was blown off to the unexcited Bell. By the time the ſecond Bell was ſtruck, the former attracted again; and this Jingling of the two Bells continued not only during the Motion of the Machine, but ſeveral Seconds after it was ſtopped. This was occaſioned by the ſmall Volume of the Clapper being able to convey away only a ſmall Quantity of the electrical Æther at each Stroke; by which it was ſome time before the *Æquilibrium* was reſtored.

58. To demonſtrate likewiſe, that the reſtoring this *Æquilibrium* is not imaginary, I ſhall mention an Experiment of a Gentleman (Mr. *Wilſon*) who has taken great Pains in theſe Inquiries. Take two Plates of any Metal, very clean and dry, whoſe Surfaces are nearly equal; hang one of them to any excited Non-electric, and bring under it upon the other a whole Leaf of Silver. When, which you find upon Application, the ſilver Leaf is attracted, lower the bottom Plate; if it is too low, you will obſerve the leaf Silver jump up and down; if too high, it will only be attracted in Part, and thereby diſſipate the electrical Power. But if you get it at the proper Diſtance, which will very eaſily be found upon Trial, the Silver will be perfectly ſuſpended at right Angles with their Planes, like the *Trapezium* of the Geometers, and touch neither of the Plates; it will be extended likewiſe to its utmoſt Dimenſions. You frequently obſerve, both at the Top and Bottom of the Silver, the electrical Fire. The ſame Effect is produced, if you reverſe the Experiment,

ment, by electrifying the bottom Plate, and ſuſpending the other over it. Now I conceive, that the Space occupied by this Leaf of Silver, is that where the *Æquilibrium* of the electrical Æther is reſtored; for if you take away the under Plate, thro' which from the Floor the Flux of this Æther is furniſhed, or if that Plate be placed upon an Electric *per ſe*, by which this Flux is prevented likewiſe, the ſilver Leaf is blown away.

59. No Body can be ſuſpended in *Æquilibrio* but from the joint Action of two different Directions of Power: So here, the Blaſt of electrical Æther from the excited Plate blows the Silver towards the Plate unexcited. This laſt, in its Turn, by the Blaſt of electrical Æther from the Floor ſetting through it, drives the Silver towards the Plate electrified. We find from hence likewiſe, that the Draught of electrical Æther from the Floor, is always in proportion to the Quantity thrown by the Globes over the Gun-barrel; or the *Æquilibrium* by which the Silver is ſuſpended, could not be maintained. I once found, that a Gentleman, at that time an Invalid, whoſe Shoes were perfectly dry, and of conſequence Originally-electrics, and who was employ'd to hold the Non-electric Plate through which the Æther was to come from the Floor; this Gentleman, I ſay, did not furniſh a ſufficient Quantity, becauſe of the Dryneſs of his Shoes, to maintain the *Æquilibrium*; and the Silver was blown away. But upon employing another to this Office, whoſe Shoes were more wet, the Æther came readily through him, and the Silver was ſuſpended. I have likewiſe found a wooden Pole, very dry, not

conduct this Æther faſt enough to keep the Silver ſuſpended. It may be imagined, that it is poſſible for the Silver to be ſuſpended, without ſuppoſing a Flux of the electrical Æther from the neareſt unexcited Non-electric, as well as from the excited one; that is, by the ſimple electrical Attraction. But to obviate this, it muſt be remembered, that the electrified Gun-barrel both attracts and repels light Subſtances at the ſame time. Can this Attraction and Repulſion be conceived without the Operation of the electrical Æther both to and from the Gun-barrel at the ſame time? Does not this point out an Afflux as well as an Efflux? Are not the electrical Repulſions as ſtrong at leaſt as the Attractions? Do not we ſee light Bodies, either between excited Originally-electrics, or excited Non-electrics, and unexcited Non-electrics, dart like a Ball between two Rackets of equal Force? It may be ſaid perhaps,

1. That the ſuſpended Silver may only ſerve as a Canal of Communication, which diſcharges the Electricity from the excited Non-electric to the unexcited one; and that when an Originally-electric is placed between the lower Plate in this Experiment and the Floor of the Room, that then the Silver is attracted only, until the lower Plate is ſaturated with Electricity, and no longer. This is as much as ſaying that this Effect ariſes from Electricity, without mentioning in what manner.

2. That this Effect is produced by the electrieal Attraction, which gives the Silver a Direction towards the excited Non electric, but that it is kept down near the unexcited one by the Force of Gravity.

vity. Was this the Cauſe, the Action of Gravity would operate as much thro' Originally-electrics as through Non-electrics.

60. But I am able to prove the Afflux experimentally, as well as the Efflux, in the following manner. When the Silver lies ſtill, though the Motion of the Globes is continued between the two Plates, one ſuſpended to the Gun-barrel, and the other placed upon an electrical Cake, a Perſon ſtanding upon the Floor needs only bring a ſmall glaſs Siphon in a Veſſel of Water, and apply the long Leg thereof near the Plate placed upon the Wax; for upon this the Silver is immediately ſuſpended; and the Water, which before only dropp'd, now runs in a full Stream, and appears luminous *. Does not, in this Caſe, the Current of the Water point out the Direction of the Current of electrical Æther?

61. When the Machine, *&c.* are placed upon Originally-electrics, if a Man, ſtanding likewiſe upon an Originally-electric, touches the Gun-barrel while the Globes are in Motion, he will receive a Snap or two; after which, though the Motion of the Globe is continued, he will perceive no more Fire from the Gun-barrel. While in this Poſture,

* This Experiment is more elegant, if the upper Plate, attracting the Silver, is ſuſpended high enough for a Perſon ſtanding upon an Originally-electric, conveniently to bring the other Plate under it with one Hand, and to hold a pewter Plate in the other. If the Originally-electric is ſufficiently thick, the Silver will not be ſuſpended; but if the glaſs Siphon in a ſmall Veſſel of Water is brought very near the pewter Plate, the Water runs into the Plate, and the Silver is immediatly ſuſpended.

Poſture, if he touches the Wood-work of the Machine with one Hand, and applies a Finger of his other near the Gun-barrel, at that Inſtant he receives the electrical Strokes. Theſe continue as long as he touches the Machine, but ceaſe upon his removing his Hand therefrom. Here we ſee a Circulation of Part of this Man's electrical Fire, which operates in the following manner. Firſt; The Man, by applying one of his Hands to the Machine, becomes a Part thereof; and, by the Motion of the Globes, Part of the electrical Fire, inherent in his Body, is driven upon the Gun-barrel; but it is inſtantaneouſly reſtored to him again, upon his touching the Gun-barrel with his other Hand. Thus he continues communicating the Fire with one Hand, and having it reſtored to him with the other, as long as he pleaſes. If, inſtead of touching the Machine or Gun-barrel, he holds his Finger near either or both of them, you ſee the Fire go out, and return back, as in a former Experiment.

62. It may be perhaps imagin'd, if one Man touches the Machine, himſelf and the Machine both being placed upon the Wax, and if another, ſtanding upon the Floor, conſtantly, or by turns, touches the Gun-barrel, that by theſe means the Man upon the Originally-electrics might be diveſted of all his electrical Fire, by conſtantly continuing the Motion of the Globes, as he receives then no Supply from the Floor. But the contrary proves true; and, after a conſiderable time, the Strokes from the Gun-barrel are as ſtrong as at firſt. But here we muſt obſerve, that the Gun-barrel ſuſpended will not contain probably at one time a thouſandth Part of the whole Quantity of this

this Man's electrical Fire: Therefore I conceive, that, as ſoon as this Man has parted with any Portion of his neceſſary, his determined Quantity, to the Gun-barrel by the Motion of the Globes, he has it reſtored to him upon any un-excited Non-electric's touching the Gun-barrel, by having the uſual Courſe of the Electricity * inverted.

63. We ſee, from many Experiments, that dry Wood does not conduct Electricity ſo well as that which is wet; and that the Man ſtanding upon the Floor, who rubs the Globes, excites the Electricity ſtronger than the Cuſhions. This I had Reaſon to conceive was owing not to any other Difference, than that of his being more moiſt, and, of Conſequence, more readily conducting the Electricity from the Floor. Therefore I order'd my Machine, and even the Cuſhions to be made damp, by cauſing wet Cloths to be placed upon ſeveral Parts thereof; and found then, that the Electricity was equally ſtrong, as when the Globe was rubbed by the Hand.

64. It remains now, that I endeavour to lay before you a Solutiou why our Bodies are ſo ſhocked in the Experiments with the electrified Water; the Difficulty thereof I confeſs ſeemed unſurmountable, until I had made the following Diſcoveries.

1. That the Electricity always deſcribed a Circuit between the electrified Water and the Gun-barrel.

2. That the electrical Fire came from the Floor of the Room.

3. That it would not paſs from the Floor quick enough for the Perſon to be ſhook, if his Shoes were dry.

4.

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* For a further Account of this Matter, ſee *Philoſ. Tranſact.* Vol. XLV. *p.* 101.

4. That the Force was increaſed in proportion to the Points of Contact of Non-electrics with the Glaſs containing the Water.

Then the Solution of this Phænomenon became more eaſy, which I take the Liberty to offer.

1. I have endeavoured to prove by Experiment*, that a Quantity of Electricity is furniſh'd from the neareſt unexcited Non-electrics, equal to that accumulated in excited Originally-electrics and excited Non-electrics.

2. This being ſo, when the Phial of Water held in one Hand of a Man is highly electrified, and he touches the Gun-barrel with a Finger of his other; upon the Exploſion which ariſes herefrom, this Man inſtantaneouſly parts with as much of the Fire from his Body, as was accumulated in the Water and Gun-barrel; and he feels the Effects in both Arms, from the Fire of his Body ruſhing through one Arm to the Gun-barrel, and from the other to the Phial. For the ſame Reaſons, if, in the Experiment with the electrical § Mine, a Man places his right Foot upon the lower ſmall Wire, and touches the Gun-barrel with his left Arm, the electrical Force is only felt in that Leg and Arm.

3. As much Fire as this Man then parted with, is inſtaneouſly replaced from the *Floor of the Room, and that with a Violence equal to the Manner in which he loſt it. To confirm this, ſee *Exp.* 54.

4. But

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* Sect. 56, 57, 58. † Sect. 60.

* See more of this in *Phil. Tranſ.* Vol. XLV. *p.* 102.

4. But this Flux of electrical Æther, either from the Floor to the Man, or from the Man to the Water, is prevented for Reaſons ſufficiently obvious, if the Glaſs containing the Water be thick; if the Points of non-electric Contact are few; if the Man is placed upon Originally-electrics; or (which is the ſame thing) if the Soles of his Shoes are dry.

5. As we find that the Electricity paſſes at leaſt equally quick through denſe Mediums, which are Non-electrics, as through thoſe which are more lax and ſpongy; may we nor therefore conclude, that the Cauſe why we feel moſt Pain at the Joints of our Arms, and in the Tendons of our Heels †, ariſes from the Texture in the Tendons and tendinous Ligaments of thoſe Parts?

65. From a due Conſideration of the *Phænomena* before us, I take the Liberty of propoſing the following Queries:

1. Whether or no the Effects we obſerve, in Bodies being drawn to and driven from either excited Originally-electrics, or excited Non-electrics, are to be attributed to the Flux of electrical Æther?

2.

† This Pain in the Heels is felt only in the Experiment with the electrical Mine; and it is not perceptible only when you touch the lower ſmall Wire with your Foot, but likewiſe if you ſtand upon Non-electrics, which touch this Wire. It has been ſtrongly felt by a Perſon ſtanding upon a Pedeſtal of *Portland* Stone near ten Inches in Height, and upon one of Metal more than two Feet. I am of Opinion, that no Maſs of Metal, of Dimenſions however great, would in the leaſt prevent the Progreſs of the electrical Power from the Water in the Phials to the Body of the Man.

2. Whether or no, that, which, from its being firſt diſcover'd in Amber, we call Electricity, electrical Æther, electrical Power, *&c.* is any other than elementary Fire?

3. Whether or no this Fire does not appear in different Forms, according to its different Modifications? Does it not, when diffuſed under a large Surface, appear to affect us as Air? When brought towards a Point, does it not become viſible, as lambent Flame? When nearer ſtill, does it not explode, and become the Object alſo of our Feeling as well as of our Hearing? Altho' it does not affect our Skin with the Senſation of Heat; does it not, by its lighting up inflammable Subſtances, ſhew itſelf to be truly Fire?

4. Whether or no this Fire is not connected intimately with all Bodies at all times, though leaſt of all, probably, with pure dry Air? Have we not found and ſeparated it from Water, Flame, even that intenſe one of Oil of Turpentine, Smoke, red-hot Iron, and from a Mixture thirty Degrees colder than the freezing Point?

5. Have we not proved its Subtility, from its paſſing through all known Bodies?

6. May we not infer its Elaſticity likewiſe from its Exploſions, from its increaſing the Motion of Fluids, as well as from its Effect in the Concuſſion of our Bodies, when we diſcharge it after we have accumulated it in Water?

7. May not the electrical Machine, from its Uſes, be denominated a Fire-Pump, with equal Propriety as the Inſtrument of *Otto Guerick* and Mr. *Boyle*, that of the Air?

8.

8. Does not the Power we are now Maſters of, of ſeeing the Separation of Fire from Bodies by Motion §, and of ſeeing it reſtored to them again, and even after that Motion has ceaſed, cauſe us rather to incline to the Opinions of *Homberg* (*a*), *Lemery* the younger (*b*), *s'Graveſand* (*c*), and *Boerhaave*,

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§ The ſetting in of the Fire to the glaſs Tubes and Globes has always, in theſe Experiments, been viſible both from the Hands and Cuſhions, by which they were rubbed. But as, till now, this Fire was conſidered as coming from the Glaſs, that, obſerved upon the Hands and Cuſhions, was always believed to be ſo much loſt by running down the Inſtruments of Friction into the Floor. I endeavoured to prevent this Loſs, by ſtanding upon Originally-electrics; and found, to my great Surprize, that ſo far from increaſing the electrical Power, by ſtopping what I conjectured was ſo much Loſs, I could excite then no Electricity at all in the Tube and Globes. This Diſappointment, which, I afterwards found, had occurred to Meſſ. *Boſe* and *Allamand*, was the Foundation of my diſcovering the Source of the Electricity, and the Manner of its Ingreſs to the Machine.

(*a*) *Homberg* du ſouphre principe. *Mem. de l'Acad. Royale des Sciences*, 1705. La matiére de la lumiére eſt la plus petite de toutes matiéres ſenſibles — elle paſſe librement au travers et par les pores de tous les corps, que nous connoiſſons. —Que tout l' univers eſt rempli de la matiére de la lumiére——J'ai mieux donnè à notre ſouphre principe le nom de matiére de la lumiére, que celle du feu, quoique ce ſoit proprement la même choſe.

(*b*) *Lemery* le fils. *Mem. de l'Acad.* 1709. p. 527. La matiére de feu doit être regardée, comme un fluide d'une certaine nature, et qui a des proprietez particulieres, qui le diſtinguent de tout autre fluide. Pag. 8.——Qu'une matiére beaucoup plus ſubtile et plus agitée, qui remplit tous les vuides de l'univers, et ne trouve point les pores ſi étroits, qui ne lui laiſſent un libre paſſage, coule inceſſamment dans les lieux où elle eſt enfermée, et entretient ſon mouvement.

(*c*) *s'Graveſand Philoſoph. Newton inſtitutiones, cap.* 1. Ignis in corpora omnia quantumvis denſa et dura penetrat.——— Corporibus

Boerhaave (*d*), who held Fire to be an Original, a diſtinct Principle, formed by the Creator himſelf, than to thoſe of our illuſtrious Countrymen, *Bacon* (*e*), *Boyle* (*f*), and *Newton* (*g*), who conceived it to be mechanically producible from other Bodies?

9. Muſt we not be very cautious, how we connect the elementary Fire, which we ſee iſſue from a Man, with the vital Flame and *Calidum innatum* of the Ancients; when we find, that as much of this Fire is producible from a dead Animal as a living one, if both are equally replete with Fluids?

10. Whether or no it is not highly probable, that, by increaſing the Number and Size of the Phials of Water in a certain manner, you might not inſtantly

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ribus ſeſe jungit —— ignem ad certam diſtantiam a corporibus attrahi — nulla novimus, quæ ignem non continent — non ignis æque facile corpora omnia intrat —— corporibus contentus in his a corporibus circumambientibus retinetur. —— Motu celerrimo ignem affici poſſe.

(*d*) *Boerhaavii Elementa Chem. de igne*, p. 187. et ſeq. — Ipſe ignis — ſemper præſens exiſtit in omni loco —— imo vero in omni corpore, etiam rariſſimo, vel ſolidiſſimo, æqualiter diſtributus hæret. — Haud ergo potui detegere, quod in rerum natura ſit vel ullum ſpatium ſine igne.

Ibid. p. 283. Huc uſque conabar —tradere ea, quæ veriſſima addiſcere potui de natura illius ignis, quem elementalem appellant philoſophi. Illum ſcilicet, ita conſiderando, prout creatus ipſe in rerum (natura) exiſtet ſeorſum, extra reliqua omnia creata, quæcunque demum ſint, corpora.

(*e*) Vide tractatum *De forma calidi.*

(*f*) *Mechanical Origin of Heat and Cold*, Sect. 2.

(*g*) See Queries at the End of his *Optics.*

inſtantly kill even large Animals by the electrical Strokes (*h*)?

66. I cannot conclude theſe Papers, without congratulating that excellent Philoſopher and learned Member of this Society the Abbé *Nollet* of *Paris*. This Gentleman, almoſt two Years ſince, in a Letter to Profeſſor *Boſe* (an Extract of which this laſt publiſhed with a Work (*i*) of his own) without the Knowledge of ſeveral Experiments ſince diſcover'd; at leaſt none of his Diſcoveries have yet fallen into my Hands, did declare his Opinion, (*k*) that the Electricity did not only proceed from the electrified Bodies, but from all others about them to a certain Diſtance; (*l*) that the Electricity, as well from Bodies electrified, as from thoſe which were not, paſſed more readily through denſe Mediums than Air; (*m*) that the Electricity is preſent in all Bodies; that

(*h*) Monſ. *Le Monnier* at *Paris* killed Birds by theſe; and with me, a Linnet and a Rat, much more than half-grown (the largeſt I was then able to procure) have been ſtruck dead.

(*i*) *Recherches ſur la Cauſe, et ſur la veritable Theorie de l'Electricité.* Wittembergue, 1745.

(*k*) *Voyez Nollet dans les Recherches, &c. du M. Boſe*, Pag. xlv.— La matiére electrique vient non ſeulement du corps électriſé, mais auſſi de tous ceux qui ſont autour de lui, juſques à une certaine diſtance.

Ibid. p. xlix. — Si vous pouvez vous convaincre comme moi, que la matiére qui va au corps électrique vient primitivement de tous le corps environnans, de l'air même, vous aurez bien plus de facilité à expliquer tous les autres effets.

(*l*) *Ibid.* p. xlvi. La matiére electrique, tant celle qui ſort du corps électriſé, que celle qui vient des environs à ce même corps, ſe meut plus facilement dans les corps denſe que dans l'air même.

(*n*) *Ibid.* p. xlvii.

(*n*) that this Matter always tends to an *Æquilibrium*, and endeavours to occupy thoſe Spaces in Bodies, which have not their neceſſary Quantity: All which Aſſertions may now be proved by Experiments.

67. You ſee, Gentlemen, by my aſſerting, that what we have hitherto called electrical *Effluvia*, do not proceed from the Glaſs, or other Electrics *per ſe*, I differ from *Cabeus*, *Digby*, *Gaſſendus*, *Brown*, *Des Cartes*, and very great Names of the laſt as well as the preſent Age. My differing from them would be Preſumption indeed, were I not induced thereto, by Obſervations drawn from a Series of Experiments carefully conducted, to which many of you have been Witneſſes, and to whom I may therefore appeal, for taking what may ſeem ſo extraordinary a Step. I have conſtantly had in View that excellent Maxim of Sir *Iſaac Newton* laid down in his *Optics*, that, " as in Mathematics, ſo in Natural Philoſophy, the " Inveſtigation of difficult Things by the Method of " Analyſis ought ever to precede the Method of Com- " poſition. This Analyſis conſiſts in making Experi- " ments and Obſervations, and in drawing general " Concluſions from them by Induction, and admitting " of no Objections againſt the Concluſions, but ſuch " as are taken from Experiments, or other certain " Truths. For Hypotheſes are not to be regarded " in Experimental Philoſophy. And although the " arguing from Experiments and Obſervations by " Induction

(*n*) *La meme.* Cette matiére tend à l'équilibre, et s'empreſſe de remplir les eſpaces, qui ſe trouvent vuides des parties de ſon eſpece.

" Induction be no Demonſtration of general Con-
" cluſions; yet it is the beſt Way of arguing which
" the Nature of Things admits of, and may be
" look'd upon as ſo much the ſtronger, by how
" much the Induction is more general. —— By this
" Way of Analyſis we may proceed from Com-
" pounds to Ingredients, and from Motions to the
" Forces producing them; and, in general, from
" Effects to their Cauſes, and from particular Cauſes
" to more general ones, till the Argument ends in
" the moſt general." I am deſirous, that what is contain'd in theſe Papers, you will be pleaſed to regard rather as the rude Outlines of a Syſtem, than as a Syſtem itſelf; which, I am in Hopes, Men of better Heads and more Leiſure will proſecute: And if hereafter, from being poſſeſſed of more Obſervations than we at preſent are Maſters of, any Opinions in theſe Papers ſhall be found erroneous, I at all times ſhall be willing readily to retract them. I rely upon your wonted Candour, and am,

With the greateſt Truth,

Gentlemen,

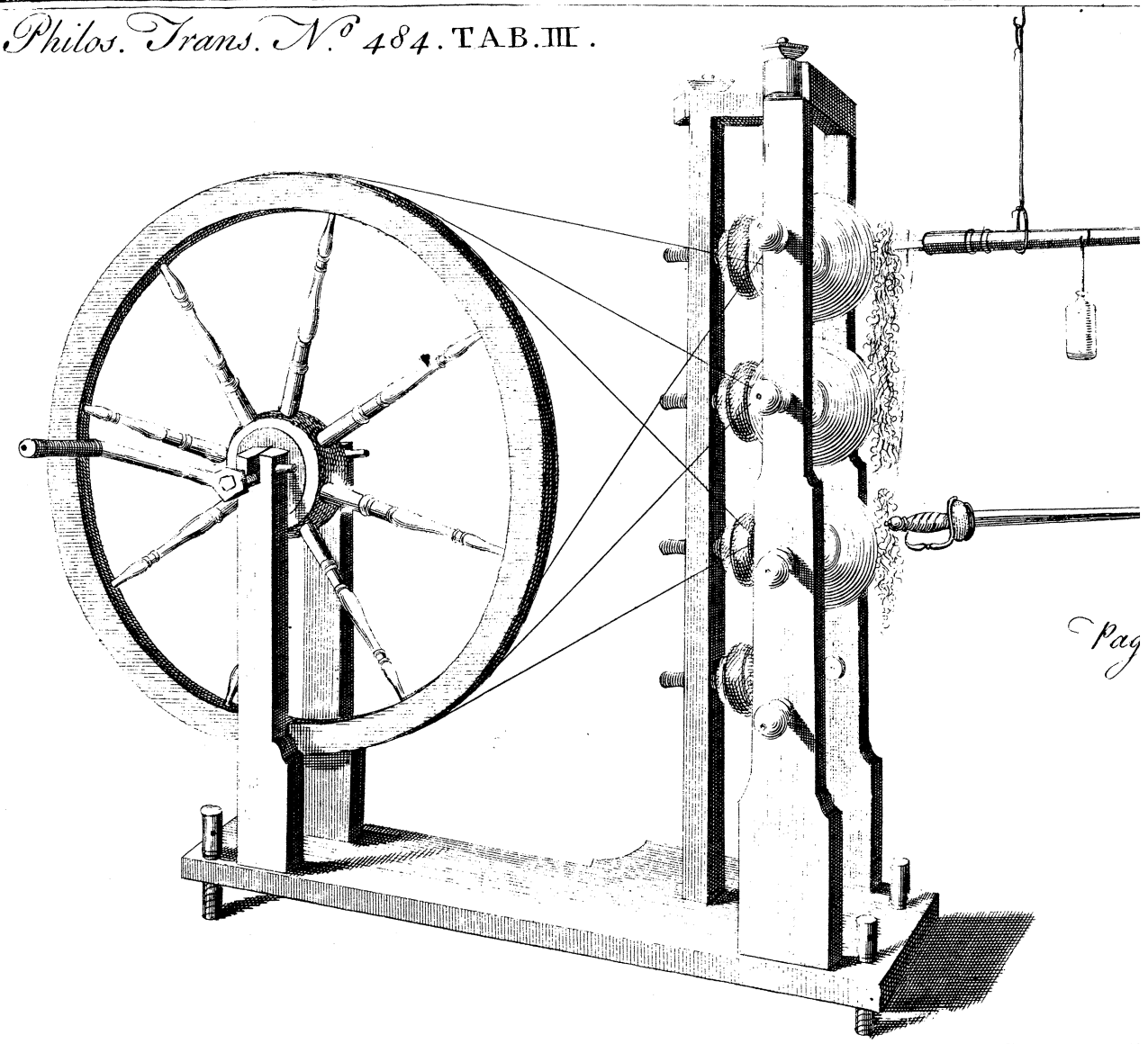
Oct. 20. 1746.

Your moſt devoted
and moſt humble Servant,

W. Watſon.

F I N I S.

Philos. Trans. N.o 484. TAB. III.



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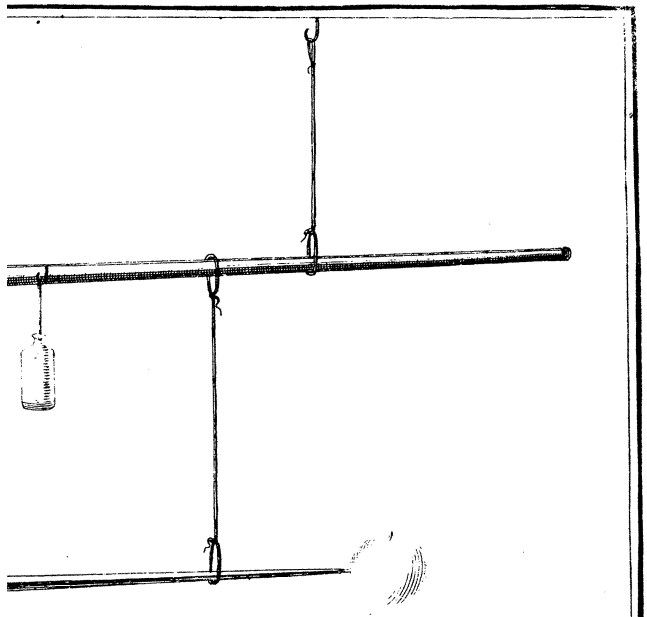

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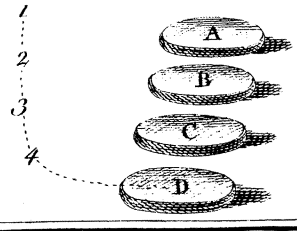

I. Mynde Sculp

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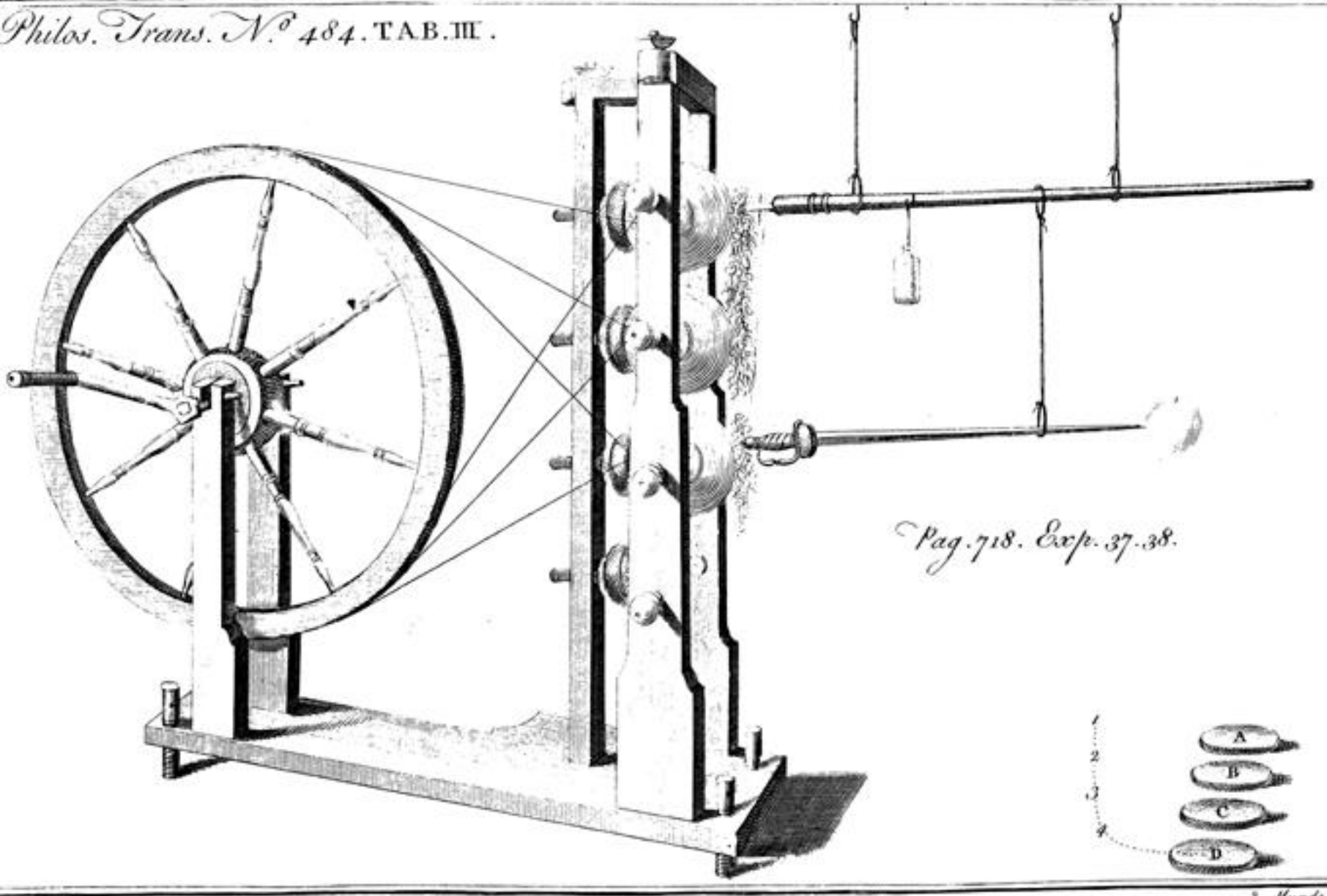

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